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Potential effects of UMTS radiation measured by near infrared imaging

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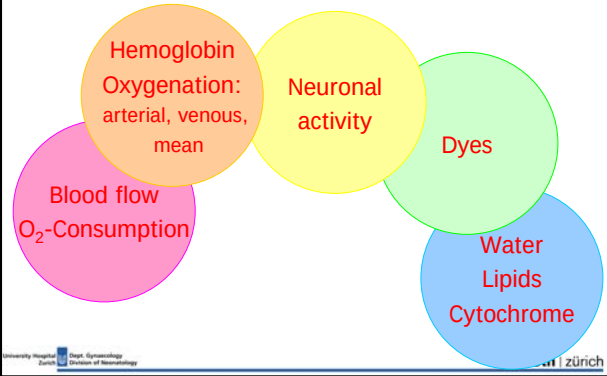
Overview

- Near infrared imaging (NIRI)
- Use of NIRI to study bioeffects of EMF
  - GSM
  - UMTS (NFP 57)
- Outlook

Non-invasive near infrared imaging (NIRI)

Picture credit: Dr. R. Mudra, Biomedical Engineering ETHZ

What can be measured?



Limitations and advantages of NIRI

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- In adults limited to outer cortex
- Limited spatial resolution
- Usually no anatomical information
- Influence of extracerebral tissue (not true for multidistance)
- Motion artifacts
- Hair needs to be brushed away

⊕

+ Non-invasive, painless
+ Non-ionizing radiation
+ Functional studies of e.g. developing brain possible
+ Continuous monitoring at high time resolution
+ Bedside applicable
+ No tracers necessary
+ Multimodal imaging with fMRI, PET, EEG & MEG
+ Not sensitive to EMF

Methods to study brain

Method	Hemo-dynamics	Neuronal activity	Time res.	Spatial res.	Tracer	Bedside	Cost
NIRI	yes	yes	ms	10mm	no	yes	low
MRI	yes	no	s	1mm	no	no	high
PET	yes	no	min	5mm	yes	no	high
MEG	no	yes	ms	cm	no	no	high
EEG	no	yes	ms	cm	no	EMI	low

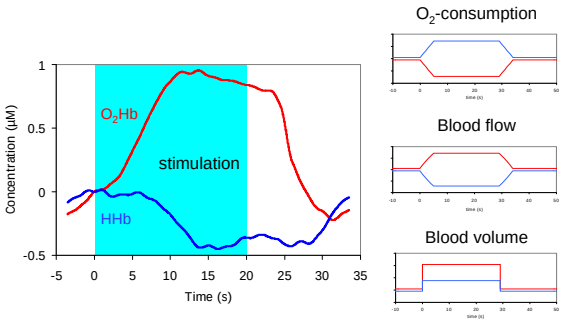
NIRI=near infrared imaging
MRI=magnetic resonance imaging, PET=positron emission tomography,
MEG=magnetoencephalography, EEG= electroencephalography

Imaging sensor

- Sources:
  - multiplexed LEDs
  - 730nm and 830nm
- Detectors:
  - PIN Photodiode
- 16 bundles

- 15 healthy term neonates
- Age median 5.5 (2 – 9 days)
- Spontaneous sleep

Grand average



Study of effects of EMF using NIRI

Introduction

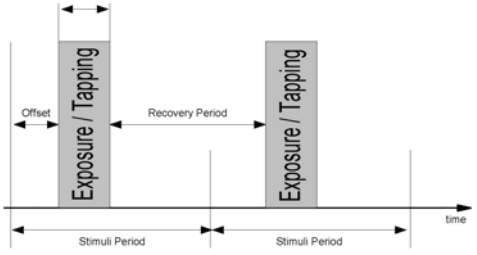
- Potential biological effects of EMF:
  - Changes in neuronal activity, which affect oxygen consumption, blood flow and volume
  - Temperature changes, which affect blood flow and volume
  - Changes in energy metabolism, which affect blood flow and volume
- Detectable by NIRI

Aims

- Do EMF affect cerebral blood circulation and oxygenation?
  - Short term effects of EMF (~60s)
  - Long term effects of EMF (~20min)
  - Dose effects
- Compare results to normal functional activity

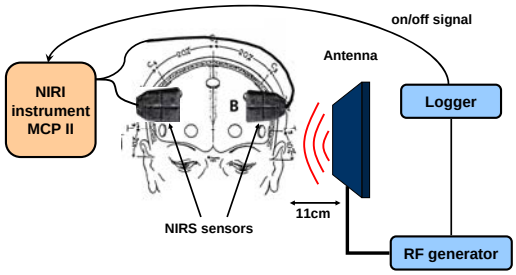
Protocol

- 20s exposure/60s recovery
- 3 exposure levels:
- On 3 different days
- 15 repetitions
- 20min duration

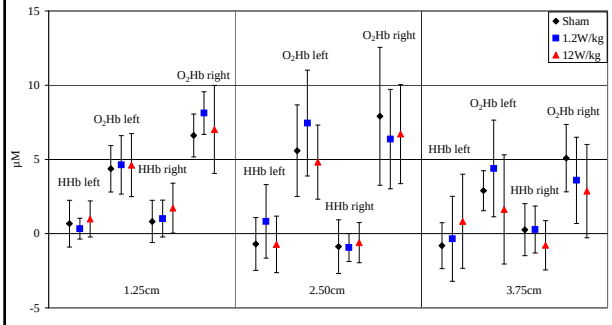


GSM Study

Set-up



Example results long term: no clear changes



NIRI is very sensitive for potential effects

Sensitivity 95%CI

Distance	1.25cm	2.5cm	3.75cm
ΔO_2Hb µM	0.120	0.147	0.198
ΔHHb µM	0.052	0.086	0.138

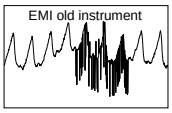
Comparison to normal functional changes

R=2.5cm	Normal activity	Compared to EMF
ΔO_2Hb µM	**0.85**	5.8x
ΔHHb µM	**0.25**	2.9x

UMTS Study (NFP 57)

Study of potential physiological effects of UMTS-EMF

1 Modification of NIRI for EMF exposure studies (completed):
- Remove influence of EMI:
  - Develop fiber optic sensors
  - Shield instrument
  - Test inertness to EMI
- Sensor arrangement that provides depth resolution



2 Exploratory phase (in progress)
- Study the influence of different parameters:
  - 4 types of exposure signal
  - Measure different locations on head
  - Duration of exposure period
  - Duration of recovery period
- Finalize protocol

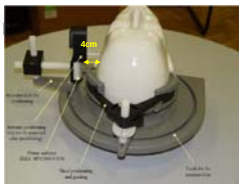
3 Confirmatory phase (future):
- Double blinded, randomized, controlled study in 16 subjects
- Comparison to effects of functional brain activity

Exposure system

Electronics of the exposure system: signal generator, amplifier, powermeter

- Provided by Swisscom Innovations
- Installed in quiet room of University Hospital Zurich
- Dosimetry
- Power levels:
  1. Sham
  2. 0.2 W/kg
  3. 2 W/kg
- UMTS signals
  1. CW, ν = 1.9GHz
  2. UMTS downlink (base station)
  3. UMTS uplink: 1 channel
  4. UMTS uplink: 6 channels

Exposure set-up



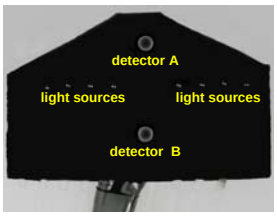
Optical measurement system

ISS Oxiplex TS

Commercially available sensor

- Commercially available ISS instrument
  - Laserdiodes (690 and 830nm)
  - Photomultiplier tubes detectors
  - Phase and intensity measurement
  - Measures absorption and scattering of tissue
  - Time resolution 50Hz
  - 2 x 8 light bundles
  - No spatial resolution
- Modification of ISS instrument
  - FPGA, microprocessor, DLL reprogrammed
  - ⇒ Time resolution 25Hz
  - ⇒ 2 x 16 light bundles
  - ⇒ Spatial resolution (Imaging) achieved

Specifically designed sensor



- Without metal
- 10m long glass fibers
- ISS instrument outside exposure chamber

⇒ No interference with UMTS radiation

Dimensions: 50x81x7mm^3

Test: negligible EMI

- Sensor on optical phantom with tissue properties
- Mean difference with and without exposure:
  - 0.0011% in intensity
  - 0.000074µM HHb
  - 0.0014µM O_2Hb
  - 1 significant light bundle of 95

Obtaining spatial and depth resolution

Spatial resolution:

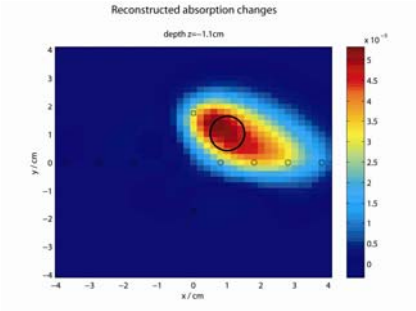
- Image reconstruction based on diffusion theory
- Modified Beer-Lambert Law

Depth resolution:

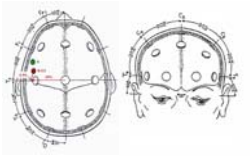
- Image reconstruction based on diffusion theory
- Multi-distance approach based on diffusion theory

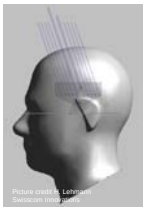
Discrimination between superficial (scalp, skull) and deep (cerebral) changes of blood flow.

Reconstruction 3D



Measurements of human subjects





Preliminary results exploratory part

- 8 subjects
- 64 measurements
- 24 preliminary analysis:
  - 8 conditions in 3 subjects

Conclusions

- Technical set-up is functioning
- Exploratory study is under way
- First results indicate significant changes, but data analysis is preliminary

Outlook

- Influence of different conditions on potential effect
- Protocols finalized
- Confirmatory study
- Set-up can be used to study other communication technologies

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